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Prevalence and Risk Factors of Ovine Lung Worm Infection in and Around Ambo, Oromia Regional State, Ethiopia

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Abstract

A cross-sectional study was conducted from October 2015 to April 2016 to estimate the prevalence of lungworm infection and to assess some of the determinant risk factors associated with ovine lungworm infections in and around Ambo, Central Ethiopia. Fecal samples were collected from randomly selected 349 sheep, kept under extensive management systems, to examine first-stage larvae (L1) using Baermann technique. Additionally, samples were collected from 44 sheep slaughtered in different restaurants and hotels to examine the presence of adult lungworm parasites. The overall prevalence recorded from fecal and postmortem examinations was 23.2% and 31.8%, respectively. A higher prevalence was observed in females (26.2%) than in males (17.7%). Age-wise, a higher prevalence (29.1%) was observed in animals greater than 6 months to 2 years old, while the lowest (13.5%) was observed in animals less than or equal to 6 months. However, the prevalence noted, both in line with age and sex categories, was not statistically significant ($P > 0.05$). On the other hand, a higher prevalence was observed in sheep with poor body condition (37.6%), followed by moderate (21.9%) and good (12.4%) body-conditioned animals, and the difference was statistically significant ($p<0.05$). Similarly, the prevalence of lungworm infection in apparently healthy groups was 17.0%, while that of the sick was 52.5% and the difference was significant statistically ($p<0.05$). The prevalence of lungworm infection during postmortem examination of slaughtered sheep was higher (31.8%) than the result obtained at coprology (23.2%). The present study confirmed that lungworm infection was a common problem among sheep in the study area. Due to its impact on production, emphasis should be given to the control and prevention of lungworm infection in the study area, like the application of repeated deworming and grazing management.

Keywords: Prevalence, Lungworm, Baerman technique, Prevalence, Sheep

Introduction:

Livestock has several benefits for humans, especially in developing nations. In Africa, small ruminant production is a significant portion of the continent's livestock industry (Rege, 1994). Of the 475 million goats and 1,614 million sheep on the globe, 95% and 65 percent, respectively, are found in developing nations. Africa is home to 205 million sheep and 174 million goats, or roughly 17% and 31% of the global population, respectively (FAO, 1993). Africa has a very diverse distribution of small ruminants; they are more prevalent in arid regions than in humid ones (Lebbie et al., 1992).

Due to minimal input requirements such as small initial capital, fewer resources, and maintenance costs such as small ruminant households in African society, these factors account for a larger share of impoverished families' total income. With marginal areas, insufficient pasture, and agricultural leftovers, they can also generate milk and meat in easily consumable quantities. Additionally, because of their rapid production cycle, they can quickly reassemble flocks following calamities and meet demand (Gatenby, 1991).

Ethiopia has a large livestock population in Africa, estimated at 34–40 million TLU. Within the country, 12% of small ruminants and 17% of cattle are found, contributing to the livelihoods of approximately 80% of the rural population (FAO, 1993 and CSA, 2009). Ethiopia is home to diverse indigenous sheep and ranks second in Africa and sixth in the world (CSA, 2009), with an estimated population of nearly 23.62 million sheep (CSA, 2008). 75% of the total sheep population is raised in highlands with altitudes above 1,500 sea levels, while the remaining 25% are reared in the lowlands (Fentahun et al., 2012). In Ethiopia, the livestock sector is the major source of income for rural communities and a significant contributor to foreign currency from exports (Gebreyohannes et al., 2013). Sheep are the dominant livestock in Ethiopia, providing up to 63% of cash income and 23% of the food substance value obtained from livestock production.

Despite this, sheep production and productivity are limited due to parasitic diseases. Lungworms are among the endoparasites frequently found in sheep and affect the production of these animals in Ethiopia and worldwide. Ovine lungworms are widely distributed throughout the world but are particularly common in countries with temperate climates and in the highlands of tropical and sub-tropical countries (Hansen, 1994). In the highland areas, infection with lungworm parasites is the common cause of high mortality and morbidity in the sheep population (FAO, 2002). Lungworm infection in sheep is caused by nematode parasites such as *Dictyocaulus filaria, Muellerius capillaris, and Protostrongylus rufescens* (Radostits et al., 2007). *Dictyocaulus filaria* is acquired by ingestion of infective larvae with herbages, but *Muellerius capillaris and Protostrongylus rufescens* are transmitted when Molluscan intermediate hosts are accidentally ingested by grazing animals (Urquhart, 1996).

The pathogenic effect of lungworms varies depending on where they are located in the respiratory tract, how many infectious larvae they ingest, and the animal's immune system. Lungworms are parasitic nematodes that are known to cause infections of the lower respiratory tract, which are characterized by respiratory distress, trachitis, bronchitis, and pneumonia (FAO, 1994). Lungworm infection manifests clinically as severe, chronic coughing to mild coughing with modestly elevated respiratory rates (Kahn, 2005). Other significant clinical indicators include weight loss, nasal discharge, dyspnea, and nausea (Radostits et al., 2007). The main parasitological method of confirming lungworm disease is by detecting the L1 stage in fecal samples using the Baermann technique, but several factors can affect larval excretion, such as season, lactation, and reproductive effort. On post-mortem examination, the air passage opened to detect adult worms in the lower respiratory tract (lung) (Girisgin et al., 2008).

Control and prevention of these parasites are therefore essential for increasing sheep production and reducing the impact of these parasites on sheep. For proper implementation of control measures, knowledge of parasitic diseases and their prevalence must be studied (Borji et al., 2012). The incidence of respiratory helminthiasis varies from place to place, depending on various risk factors. Several studies were conducted to determine the prevalence and associated risk factors of ovine lungworm infections in different parts of Ethiopia and indicated varied infection prevalence.

Therefore, the objectives of this study were:

- To estimate the prevalence of lungworm infection in sheep in the study area
- To assess potential risk factors of ovine lungworm infection

Materials and Method:

Description of study area

The study was conducted from October 2015 to April 2016 in and around Ambo, West Shewa zone, Oromia regional state. The town is located in the central part of Ethiopia, at a distance of about 110 km from Addis Ababa in the west. The area is situated at latitude of $8^{o}47$ to $9^{o}20°N$ and a longitude of $37^{o}32°$ to $38^{o}3°E$. The altitude of the area ranges from 1300-3330 M.A.S.L. The area receives a mean annual rainfall ranging from 800-1000mm with an average of 900 mm, of which 70% (long rain) falls from June to September and 30% (short rain) falls from February to April. The monthly average minimum and maximum temperatures are $15^{o}C$ and $29^{o}C$, respectively. The study area comprises 35.3% highland, 14.7% lowland, and 50% midland from the total coverage. The livestock population in the area is estimated to be 133,202 cattle, 52,714 sheep, 43,339 goats, 15,456 donkeys, 9,655 horses, 294 mules, and 138,754 poultries. There are also about 6,202 beehives in both traditional and modern production systems.

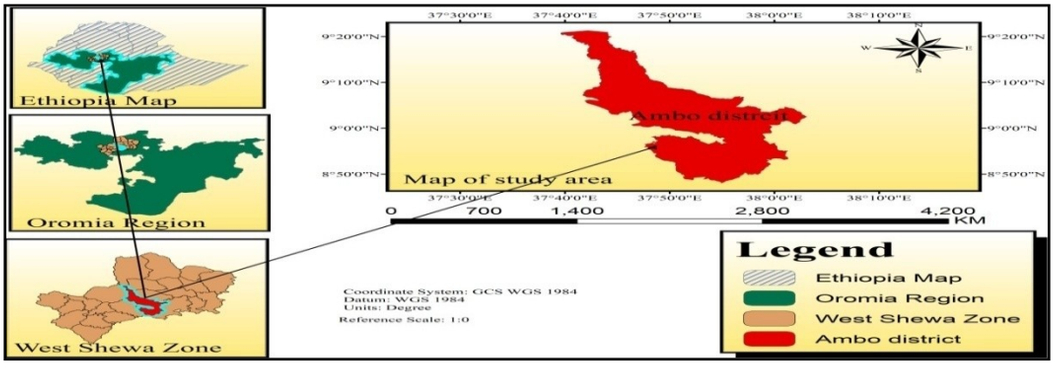

Figure 1: Map of Ethiopia shows study area

Study Population

The study population consisted of 349 sheep randomly selected from the sheep populations in the study area. All the study animals were local breeds and were kept under a traditional management system where animals were allowed to graze freely in the daytime and stay in the pen at night. Of the total sampled animals, 225 were female and 124 were male. The farmers' answers were used to estimate the animals' ages, which were then double-checked by looking at their teeth. The animals were divided into three age groups: younger than six months, between six months and two years, and more than two years, based on the replies. In each age group, there were 37, 127, and 185 animals, in that order. The Ethiopia Sheep and Goat Productivity Improvement Programme (Foreyt, 2013) were followed in the rating of body condition.

The assessment revealed that 105, 151, and 93 animals had good, moderate, and poor BCS, respectively. With regard to clinical respiratory signs, 61 animals had clinical respiratory symptoms, while 288 animals appeared apparently healthy.

Study design

The study was a cross-sectional study conducted in and around Ambo town, both among the field population and sheep brought for slaughter at hotels and restaurants. The Biodata of the individual animals were collected both from clinical assessments and owner information, where appropriate.

Sampling method and Sample size

The sampling method used a simple random sampling technique to select the animals and determine the sample size. The total sample size was calculated using the following parameters: 95% confidence level (CI), 5% desired level of precision, and 34.90% prevalence of lungworm in naturally infected sheep of the Ambo district, as confirmed by (Beyene et al., 2013). The sample size was determined using the formula provided by Thrusfield (2005).

$$n = \frac{1.96^2 Pexp\ (1-Pexp)}{d^2}$$

Where, n = required sample size

Pexp = expected prevalence

d = desired absolute precision

Therefore, based on the above formula, the total sample size of sheep was calculated to be 349.

Laboratory assay

Coprological examination

Fresh fecal samples were directly collected from the rectum of individual sheep using disposable gloves. The samples were placed in a universal bottle and packed in an icebox. Information on various risk factors, such as date of sampling, sex, body condition, clinical respiratory signs, and age of individual animals, was properly recorded during sample collection. Each bottle was properly labeled to correspond with the animal's identity. The sample was then transported to the Ambo University Veterinary Laboratory Technology. The techniques recommended by (Hendrix, 2006) were used for the identification of lungworm larvae from the collected samples. In the laboratory, the conventional method of the Baermann technique was employed for the detection of lungworm larvae. Fresh feces were weighed and wrapped in gauze, fixed to a string in a beaker filled with water. The Baermann apparatus was left in place for 24 hours. The larvae leave the feces, migrate through the gauze, and settle at the bottom of the glass. After removing the supernatant, the sediment was examined under a lower-power microscope.

Post mortem Examination

For the postmortem examination, the lungs of sheep were collected from sheep slaughtered at different restaurants and/or hotels in Ambo town and transported to Ambo University Veterinary Laboratory Technology after slaughter for examination of adult lungworms. The sex, body condition, and date of sampling of the slaughtered animal were labeled. The air passages were opened, starting from the trachea down to the bronchi, with fine, blunt-pointed scissors to detect the parasites.

Data Management and Analysis

The data was recorded on special formats prepared for this purpose routinely, entered into a Microsoft Excel spreadsheet, and summarized using descriptive statistics. Logistic regression analysis (both univariable and multivariable analysis) was employed using STATA version 11 to analyze the association between individual as well as group risk factors against lungworm infection. The assumed risk factors are considered significant when the p-value is less than 0.05. Age, sex, clinical respiratory signs, and body condition score were considered as risk factors to see their association with the prevalence rate.

Results and Discussion:

Coprological Examination

A total of 349 sheep were examined for lungworm infection using the Baermann technique in Ambo town and its surroundings. The survey showed an overall prevalence of 23.2%. In this study, a number of hypothesized risk factors, including age, sex, body condition, and the presence or absence of respiratory clinical signs, were considered to observe the trend of prevalence. Accordingly, the prevalence in males was 17.7%, while that of females was 26.2%. Similarly, the prevalence in lamb was 13.5%, young adults were 29.1%, and adults were 21.1%, and no statistically significant difference was noted between categories in the respective risk factors ($P > 0.05$).

Among the hypothesized risk factors, the infection prevalence was observed to be associated with sheep body condition. Accordingly, the prevalence was noted to be 12.4% for good, 21.9% for moderate, and 37.6% for poor body condition. The difference noted was significant statistically ($P<0.05$). Similarly, the prevalence of lungworm infection in apparently healthy groups was 17.0%, while that of the sick was 52.5%, and the difference was significant statistically ($p<0.05$).

Table 1: Prevalence of lungworm infection in ovine hosts in relation to different risk factors (variables)

Factors	Category	No. of examined	Proportion (%)	95% CI
Age	≤ 6 month	37	5 (13.5)	2.3 – 24.7
	> 6 month-2 year	127	37 (29.1)	21.2 – 37.1
	>2 year	185	39 (21.1)	15.2 – 27.0
Gender	Female	225	59 (26.2)	20.4 – 32.0
	Male	124	22 (17.7)	11.0 – 24.5
BCS	Poor	93	35 (37.6)	27.7 – 47.6
	Moderate	151	33 (21.9)	15.2 – 28.5
	Good	105	13 (12.4)	6.0 – 18.7
Resp. cl. sign	Showing resp. cl. sign	61	32 (52.5)	39.8 – 65.1
	Apparently healthy	288	49 (17)	12.7 – 21.4
Total		349	81 (23.2)	19.1 – 28.0

The data were further regressed in a univariable logistic regression analysis (Table 3), and those predictors with a p-value less than or equal to 0.25 were further subjected to a multivariable logistic regression analysis. As all four predictors considered in univariable logistic regression fulfilled the benchmark criteria, they were all subjected to multivariable regression analysis; however, body condition score and status of respiratory signs fitted the final model significantly (Table 2).

Table 2: Univariable logistic regression analysis of different risk factors with lung worm infection in sheep

Factors	Category	No. of examined	Proportion (%)	OR	95% CI for OR	P – value
Age	≤ 6 month	37	5 (13.5)	Ref		
	> 6month-2 year	127	37 (29.1)	2.6	0.95 – 7.3	0.062
	>2 year	185	39 (21.1)	1.7	0.6 – 4.7	0.296
Gender	Female	225	59 (26.2)	Ref		
	Male	124	22 (17.7)	0.6	0.4 – 1.45	0.074
BCS	Poor	93	35 (37.6)	Ref		
	Moderate	151	33 (21.9)	0.5	0.26 – 0.81	0.008
	Good	105	13 (12.4)	0.6	0.11 –0.48	0.000
Resp.cl. sign	Apparently healthy	288	49 (17)	Ref		

	Showing resp. cl. Sign	61	32 (52.5)	5.4	2.98 – 9.7	0.000

Table 3: Multivariable logistic regression analysis of different risk factors associated with lung worm infection in sheep

Factors	Category	No. of examined	Proportion (%)	OR	95% CI for OR	P – value
BCS	Poor	93	35 (37.6)	Ref		
	Moderate	151	33 (21.9)	0.5	0.29 – 0.98	0.045
	Good	105	13 (12.4)	0.29	0.13 – 0.63	0.002
Resp. cl. sign	Apparently healthy	288	49 (17)	Ref		
	Showing resp. cl. Sign	61	32 (52.5)	4.5	2.4 – 8.5	0.000

47.1

Post mortem examination

A total of 44 sheep were examined through postmortem examination in Ambo town in different restaurants. Out of these, 14 (31.8%) were positive for lungworm infection (Table 4).

Table 4: Postmortem based Lung worm infection prevalence in sheep

Factors	Category	No. of examined	Proportion (%)	95 % CI
Sex				
	Female	18	44.4	6.1 – 40.1
	Male	26	23.1	20.1 – 68.7
BCS				
	Poor	5	8	3.96 – 20.3
	Moderate	22	27.3	7.7 – 46.9
	Good	17	23.5	2.1 – 45
Total		44	31.8	19.4 – 47.1

The comparison of the overall prevalence of lung worm infection was found to be higher in a postmortem examination (31.8%) than in a Coprological examination (23.2%) (Table 5).

Table 5: Coproscopic and post mortem result of lung worm infection in sheep

Type of examination	No. of examined	Proportion (%)	95% CI
Coproscopic	349	81 (23.2)	19.1 – 28.0
Post mortem	44	14 (31.8)	19.4 –

Lungworm infection (verminous pneumonia) is a chronic parasitic disease that affects the respiratory systems of animals. This results in substantial economic loss due to unthriftiness, loss of body condition, reduction of growth rate, poor skin quality, morbidity, and mortality by predisposing the animal to secondary infection (Radostits et al, 2000). The current study revealed the importance of lungworm parasites in and around Ambo in all indigenous breeds of sheep kept under an extensive traditional management system. Of the total sheep examined, an overall prevalence rate of 23.2% and 31.8% was recorded by fecal and postmortem examinations, respectively. This overall prevalence agrees with the work done by other researchers, who reported 22.7% in and around Bahir-Dar (Dawit, 2009); 21.57% in and around Atsbi (Tegegne et al., 2015); 25.78% in Banja District and 22.1% in and around Wolaita Soddo (Rahmeto et al., 2016).

However, the present finding was lower compared with the findings of (Foreyt, 2013) in three peasant associations from some areas of the country: (Moges et al., 2011) in Wogera District; (Bekele and Aman, 2011) in Tiyo District; and (Tefera and Mekuria, 2016) in Debre Birhan, who reported 34.90%, 67.69%, 57.1%, and 56.3%, respectively. On the other hand, the present report was higher than (Selam et al., 2015) in and around Wukro; (Denbarga et al., 2013) in and around Bahir-Dar; and (Ibrahim and Godefa, 2012) in Mekelle town, reporting a prevalence of 13.1%, 17.5%, and 13.4%, respectively.

The differences in the prevalence of lungworms in sheep in the above studies might be associated with differences in methods employed in the detection of lungworm larvae, the difference in the study areas attributed to climatic factors like humidity and weather and other factors that favor the survival of the larvae of the lungworm and the sample size variation used by researchers.

The reason for the low prevalence of the disease in this study could be attributed to the establishment of an open-air clinic in rural Kebeles, an increase in the number of private veterinary pharmacies, and increased farm awareness to deworm their sheep. The reason for the increase in prevalence in this study could be explained by the fact that all earlier researchers conducted their research in different management systems, but in the present study only extensive management types were examined. A higher prevalence of infection was noted where the husbandry of sheep was extensive type than in the semi-intensive type because sheep with extensive management type have a higher chance to ingest the intermediate host (snail and slugs) for lungworms with indirect life cycles (*Protostrongylus rufescens and Muellerius capillaries*) or are they possibly infested with larvae as well as easily obtained lungworms (D. filarial) from the herbage (Soulsby, 1982).

The study showed a higher level of prevalence was observed in female (26.2%) animals compared to the level of prevalence observed in male animals (17.7%), with an insignificant difference ($p > 0.05$). This result agrees with the earlier study of (Addis et al., 2011) in Gondar town and (Eyob and Matios, 2013) who reported an insignificant difference in lungworm infection between sexes. However, Ibrahim and Godefa (2012) reported significant variation in the infection rate of lungworms in males and females. The difference may be due to the improper distribution of sample selection between the two sexes, as observed by (Addis et al., 2011), where almost all female sheep were sampled.

Regarding age, a higher prevalence of lungworm infection was observed in the groups of >6 months to 2 years (29.1%) as compared to age groups of less than or equal to 6 months (13.5%) and greater than 2 years (21.1%). The reasons for this lower proportion in the age group of ≤ 6 months could be attributed to the sampling of a small and disproportionate number of animals or might be associated with the infrequent grazing behavior of animals less than 6 months of age and the acquired resistance of adult animals. Accordingly, as the age of animal's increases, their susceptibility to lungworm infection decreases (Urquhart, 1996).

The body condition of animals was found to be significantly associated with the prevalence of lungworm infection in both univariable and multivariable logistic regression analyses. A higher infection rate was observed in animals with poor body condition as compared to other groups. This, in part, may be attributed to the nutritional status of the animal. The odds of animals with medium and good BCS (OR=0.5, 95% CI (0.29, 0.98); OR=0.29, 95% CI (0.13, 0.63), respectively, are less likely to be infected with lungworm than poor body-conditioned animals. The finding was in agreement with the reports of (Marshet et al., 2014) in and around Wukro, (Tegegne et al., 2015) in Banja District, and (Tefera and Mekuria, 2016) in Debre Birhan.

This study was conducted in the dry season, when feed shortages are a serious problem for sheep kept under an extensive management system in Ethiopia. Therefore, in the dry season, free-ranging animals are not able to meet their maintenance requirements and lose a substantial amount of weight. It is well known that poor nutrition lowers both the resistance (ability to resist the parasites) and resilience (ability to tolerate or ameliorate the effects of the parasite) of the animal, thus enhancing the establishment of worms and increasing the prevalence in poorly conditioned animals (Walkden-Brown and Kahn, 2002; Kahn, 2005). In connection with lungworms, it is reported that poorly nourished animals appear to be less competent at getting rid of lungworm infection, although it is not unusual for well-fed animals to succumb to lungworm infection (López et al., 2013).

The prevalence of lungworm infection by coproscopic examination was significantly higher (52.5%) in animals showing clinical respiratory signs than those that were apparently healthy (17.0%). The odds ratio (OR) of infection in animals that showed clinical respiratory signs was 4.5 times higher than that of sub-clinically infected animals. This report is consistent with that of Eyob and Matios, 2013 and Foreyt, 2013. The occurrence of disease without clinical signs earlier would shed larvae without showing clinical signs and those that show clinical signs but without larvae could be due to failure of procedures and the existence of other disease conditions that is differential to verminous pneumonia. As a result, animals that show clinical respiratory signs have a high chance of being infected with a lungworm infection.

The prevalence of lungworm infection at postmortem examination of slaughtered sheep was higher (31.8%) than the result obtained through coprology (23.2%). This finding is consistent with the observations of Denbarga et al., 2013 and Fentahun et al., 2012 but not in agreement with the reports of (Addis et al., 2011). This difference could be attributed to the difficulty in detecting these nematodes by coproscopic methods (Girisgin et al., 2008) and may be due to a lower number of female animals examined compared to males in the postmortem examination.

Conclusion:

The result of the present study showed that lungworm infection is a problem for sheep in and around the Ambo area. In the present study, the infection prevalence of lungworms was estimated to be 23.2% on Coprological and 31.8% on a postmortem test. There was no significant

difference between the age and gender categories of animals in the study area. The prevalence noted along body condition status was different statistically. A higher prevalence was recorded in those sheep with poor body conditions than in those with medium and good body conditions. Although most sheep infected with lungworms are clinically characterized by respiratory signs, some sheep appeared apparently healthy. A higher prevalence was observed by postmortem examination than by coproscopic examination.

In light of the above findings, the recommendations are forwarded:

- ✓ Regular Strategic deworming practices need to be adopted
- ✓ Sick individuals and sheep with poor body condition need to be treated
- ✓ The efficacy of anthelmintic in use has to be monitored regularly

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Authors' Contributions:

All authors made a substantial, direct, and intellectual contribution to the work.

Conflict of interest:

The authors declare that they have no conflict of interest.

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